



THE EFFECT OF USING RUBBER TIER AND GLASS WASTE ON THE PROPERTIES OF CEMENT MORTAR

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Abstract: This research studies the effect of rubber tier waste and waste glass together on the properties of cement mortar and used mixing ratio (1: 3) and has been added rubber tier waste ratio are (10%, 20%, and 30%). Has been added waste glass ratio are (10%, 20% and 30 %) and also added rubber tier waste and waste glass together ratio are (10%, 20% and 30%) by weight of the replacement of cement. This study includes mechanical properties such as compressive strength and physical properties such as water absorption, density and also setting time. The results obtained from the study that compressive strength decreases when increasing the percentage of additives of mortar. The water absorption increased when the percentage of additive is increased. The density decrease when both percentage of additive increase in mortar cement. Also, the setting time increases when the percentage of additive is increase.

Keywords: Cement mortar, Rubber tier waste, Glass waste, Compressive strength, Water absorption, Setting time, Density.

تأثير استخدام مخلفات الاطارات المطاطية والزجاج على خواص مونة الاسمنت

الخلاصة: هذا البحث يدرس فيه تأثير مخلفات الاطارات المطاطية ومخلفات الزجاج معا على خواص مونة الاسمنت ويستخدم نسب الخلط (3:1) ويضاف كلا على حده من مخلفات الاطارات المطاطية ومخلفات الزجاج بنسب (10%، 20%، و30%) وزنا استبدال من الاسمنت وكذلك إضافة كل من مخلفات اطارات المطاط ومخلفات الزجاج معا إلى مونة الاسمنت بنسب (10%، 20%، و30%) وزنا استبدال من الاسمنت. هذه الدراسة تتضمن اختبار خصائص ميكانيكية مثل مقاومة الانضغاط وخصائص فيزيائية مثل امتصاص الماء والكثافة وزمن التجمد. النتيجة المستحصلة من هذه الدراسة ان مقاومة الانضغاط تقل بزيادة نسب المضافات إلى مونة الاسمنت. الامتصاصية تزداد عند زيادة نسب المضافات لمونة الاسمنت. الكثافة تقل عند زيادة نسبة كلا من المضافات معا. وايضا زمن التجمد يزداد عند زيادة نسب المضافات.

1. Introduction

Due to limited availability of natural resources because of the rapid development of civilization that leads to a loss of conventional construction materials. On the other hand energy consumed for the production of conventional building construction materials pollutes the air, water and land.

Recently increasing demand for the building construction materials with energy efficient, there is a requirement to implement environmentally proper technologies, cost-effective, and upgrading modern techniques that uses with available local

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construction materials. in the most developed and developing countries masses of controlled waste from industrial, commercial and household are disposed in landfill sites causing environmental problems with a rise in costs of landfill [1].

Concrete is generally utilized as a part of the development worldwide and the consumption of natural resources of concrete production is a problem especially when the construction materials cost rises due to demand increases on these materials [2].

One of the solutions to this problem is reducing the natural resources in concrete and substituted by incorporating recycled material, this procedure can assistance to diminish the construction cost and in another hand reduce the quantity of dumping material into landfill.

Waste materials for example waste glass, recycled plastic, wood ash, rice hush ash are materials that can use in the concrete material.

Also many disposal materials affect the environment such as vehicle tires which can be used as recycling material [3].

Acceptable workability limits of Rubber particles when it used to substitute entire aggregate is up to 50%, as a results of these limits, strength of concrete is proportionally reduced with replacement of rubber particles in the mixture, for example in spite of concrete compressive strength is reduced with addition rubber particles but that can be equalized by plastic and ductile failure instead of brittle failure that found in the normal concrete, in addition to that concrete with rubber particles has better resistance with almost negligible shrinkage [4].

the acceptable strength of concrete can be achieved with rubber particles content must not exceed 20% of entire aggregate volume.

Microscopic analysis shows that the hydrophobe and heterogeneous rubber particle affected in cement hydration process and as results cause a loss of compressive strength [5]. concrete density can increase (useful in strength) by using rubber industry waste from which known as carbon black, where has been used as an additive it acts as filler Due to its smaller size leading to diminishing of the concrete permeability [6].

Different forms of Glass that can be found in common products have a limited lifetime (disposed of after its usage) such as cathode ray tubes, bulbs, bottles, windshields, jars, and windows, etc., thus became an integral part of our life. The present treatment of non-recyclable glass is still to landfill, and because glass is a non-biodegradable material, these landfills non-biodegradable not establish an environmental solution to this problem [7].

Subsequently, in order to avoid environmental problems such as landfilling or stockpiling, non-biodegradable necessity be recycled. Utilization of waste glass has attracted construction industry worldwide due to consumption of concrete in large quantity for widespread construction sites [8].

The aim of this research is to study the effect of waste rubber tier and waste glass together on the properties of mortar as a partial replacement of cement.

2. Experimental Work

2.1. Materials

1. Ordinary Portland cement was supplied from United cements Company, Tasluja Bazian, Sulaymaniyah. The chemical composition and physical properties of the cement shown in table (1) and (2). Which done in the National Center for Construction Laboratories (NCCL) according to the Iraq specification (I.Q.S) No. 5 1984 [9].
2. Fine aggregate: natural sand from Al-Ekadir region in Iraq and complying with the standard Iraqi No. 45 of 1984 [10]. Table (3) shows the properties of the fine aggregate.
3. Waste rubber tier used for small cars (tires Babylon), the max particle size is 4.75 mm. The chemical composition and some properties show in table 4.
4. Waste glass in the present research is the waste of window glass and its ground in the laboratory. The max particle size is 4.75 mm. The chemical composition and physical properties show in table 5. Table 6 shows the grading of particles size (fine aggregate, rubber tire waste, glass waste).
5. Water used in all mixing and curing is drinking water.

Table1. Chemical composition of ordinary Portland cement

Oxides composition	Content Wt%	Specification limits
SiO ₂	18.81	-
AL ₂ O ₃	5.26	-
Fe ₂ O ₃	3.87	-
CaO	62.85	-
MgO	2.84	< 5%
SO ₃	2.70	< 2.8%
L.O.I.	1.84	< 4%
I.R.	1.07	< 1.5%
L.S.F.	0.80	-

Table2. Physical properties of ordinary Portland cement

Physical Properties	Test result	Specification limits
Specific surface area (Blaine Method), m ² /kg	330	≥ 230
Setting time (Vicat Apparatus),		
Initial setting, hr: min	1:15	≥ 00:45
Final setting, hr :min	3:08	≤ 10:00
Compressive strength, MPa		
3 days	25.13	≥ 15.00
7 days	34.6	≥ 23.00
Soundness (Autoclave Method), %	0.09	≤ 0.8

Table3. The properties of fine aggregate.

properties	Test results	Limited to the Iraqi specification
Specific gravity	2.65	-
Sulfate content %	0.12	≤ 0.5
Absorption%	2.32	-
Chloride content %	0.02	≤ 0.1

Table4. The chemical composition and properties of rubber tier waste.

Composition	Content %	Properties	Test result
Rubber hydroCarbon (SBR)	48	Specific gravity	0.92-0.95
Carbon black	31	Apparent density (gm/cm ³)	0.45
Acetone extract	15	Tensile resistance (Mpa)	4.2-21
Ash	2	Speed of Combustion	Very slow
Residue Chemical balance	4	Impact effect	Nil

Table5. The chemical composition and physical properties of glass waste.

oxides composition	Content %	Physical properties	Result
SiO ₂	67.72	Specific gravity	2.19
Al ₂ O ₃ + Fe ₂ O ₃	3.40	Density kg/m ³	1672
CaO	6.90	Finesse modulus	2.36
SO ₃	0.17	Absorption	0.39
Na ₂ O + K ₂ O	10.75	Color	white
MgO	6	Pozzolanic index%	80

Table6. Grading of fine aggregate, rubber tire waste& glass waste

Sieve size(mm)	Cumulative passing%			Limit of Iraqi specification No.45/1984
	Sand	Rubber tire waste	Glass waste	
4.75	97	97	98	90-100
2.36	78	90	87	75-100
1.18	56	81	77	55-90
0.06	34	40	64	35-59
0.30	10	20	20	8-30
0.15	1	4	7	0-10

2.2. Properties of mortar mixture

- 1- Using a different percentage of waste rubber tire (WR) (10%, 20%, 30%) which has been added to cement mortar.
2. Using the same percentage of waste rubber tire (WR) (10%, 20%, 30 %) from waste glass (WG), which have been added to cement mortar.
3. Using a percentage of (WR+WG) (10%, 20 %, 30%), which have been added to white cement mortar.
- 4- Water / cement ratio is (0.5) has been added for all

Table7. Mix proportions

Mix type	cement	sand	w/c	rubber tire waste	Glass waste
M	1	3	0.5	-	-
MT1	1	3	0.5	10	-
MT2	1	3	0.5	20	-
MT3	1	3	0.5	30	-
MG1	1	3	0.5	-	10
MG2	1	3	0.5	-	20
MG3	1	3	0.5	-	30
MTG1	1	3	0.5	5	5
MTG2	1	3	0.5	10	10
MTG3	1	3	0.5	15	15

2.3. Tests Methods

2.3.1. Compressive strength

This test was determined according to (ASTM: C109M – 07^{e1})[11] by using 50x50x50 mm. testing cubes were experienced by using the compressive digital machine (ELE-Auto test) of capacity 200KN. The test was conducted at age 28 days. The average of three cubes was adopted at each test.

2.3.2. Absorption test

The aim of this test to demonstrations the pores in the composite material. Specimens were weighted after removed from the mold and then immersed in water for (28 days) and then model is weighed after being removed from the water and dried with a dry cloth to become saturated surface dry.

2.3.3. Density test

The density of cement mortar cubes (g/cm^3), is found by weighting these cubes and dividing the values (mass in grams) by volume of these cubes (50x50x50) mm.

2.3.4. Setting time test

Standard Vicat apparatus is used for the determination of setting time according to (ASTM: C807-13)[12] for cement mortar and when the mortar is mixed with the waste tire, waste glass and waste tire + waste glass together.

3. Results and Discussion

3.1. Compressive Strength

The results of the compressive strength of mortar cubes at 28 days of waste rubber tire shown in fig (3-1) that the compressive strength reduces as the percentage of WR increase. The reduction in strength mainly depends on the bonding between cement and aggregates, size and hardness of aggregates [13].

The compressive strength when added the Waste glass on the mortar show decrease when increase the ratio of waste glass because when it crushed to a very fine particles powder, and that lead to SiO_2 to react chemically with alkalis component in the cement, and this reactions in turn form cementitious product that assistance and contribute to strength improvement.

Also it may be due to the glass powder effectively filling the voids and giving rise to dense concrete [14].

The compressive strength when added (WR+WG) on the mortar cement show decrease when increasing the percentage of them because the voids are also increased with mixtures containing waste rubber and waste glass to its strong influence on other components of the mortar.

Table 8. The result of compression strength test

Mix type	Compressive strength (MPa)
M	39.33
MT1	36.8
MT2	32.9
MT3	30.2
MG1	40.2
MG2	34.8
MG3	28.9
MTG1	38.3
MTG2	36.7
MTG3	29.5

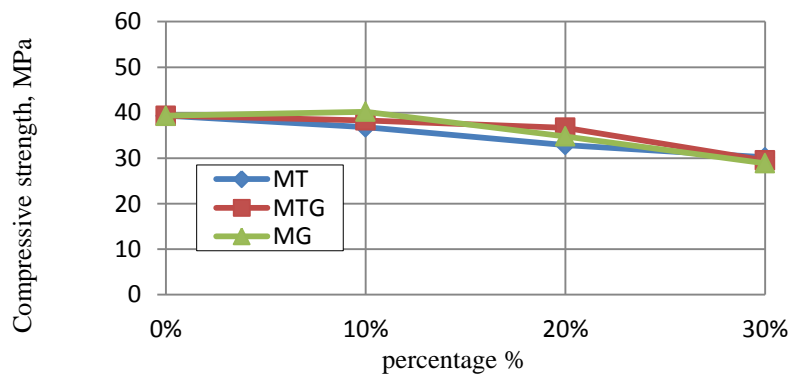


Fig (3-1): Effect of WR, WG content on compressive strength of cement mortar at 28 day ages.

3.2. Water Absorption

In fig (3-2) show increase the water absorption at 28 ages when added the WR, WG and also added WR+WG together on the mortar. Because of increasing waste materials, this waste particles permit water to penetrate through the interface voids between the cement mortar and the additives. In addition, the weakness of bonding between particles will increase absorption. Composite Water absorption test can classify as an important factor in determining composite durability. Commonly, superior protection to reinforcement additive within composites materials is achieved with composite with minimum water absorption. However the values obtained from this study suggest the performance seems to depend on the form and fineness of the waste glass and waste tire used [1].

Table9. the result of water absorption test

Mix type	Water absorption (%)
M	4.8
MT1	5.34
MT2	7.9
MT3	10.3
MG1	5.8
MG2	8.7
MG3	12
MTG1	5.5
MTG2	8.12
MTG3	11.4

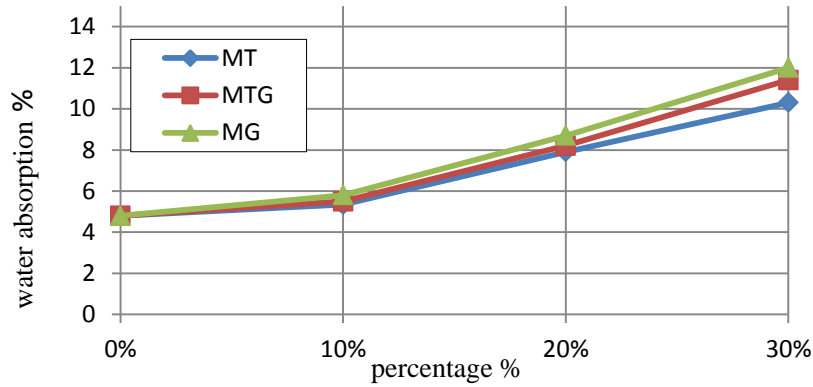


Fig (3-2): Effect of WR, WG content on the water absorption of cement mortar at 28 day ages.

3.3. Density

The results of the density shown in fig (3-3) that the density reduces as the percentage additives increases. Normally, density inversely proportion with percent replacement in another term as a percent of replacement increases leads to density decreases because the waste rubber and waste glass have less specific gravity than sand.

Table10.the result of density test

Mix type	Density (g/ cm ³)
M	1.99
MT1	1.86
MT2	1.78
MT3	1.7
MG1	1.81
MG2	1.73
MG3	1.66
MTG1	1.77
MTG2	1.65
MTG3	1.63

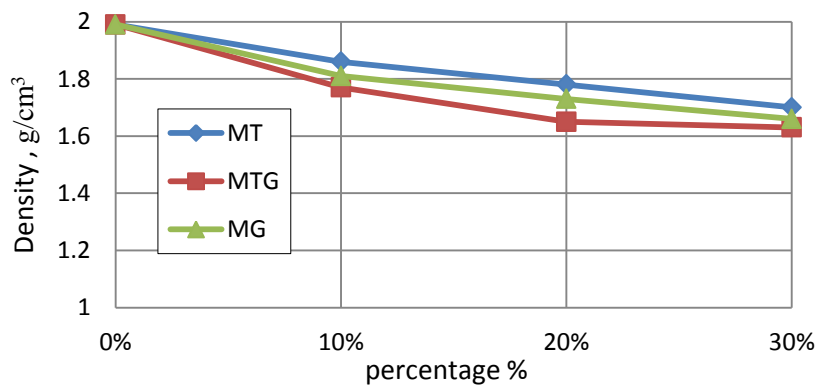


Fig (3-3): Effect of WR, WG content on the density of cement mortar at 28 day ages.

3.4. Setting Time

In fig (3-4) the results showed clear indication that incorporating waste rubber in cement mortar increased the initial and final setting time.

Since incorporating waste rubber delayed the initial setting time and overall hardening process, final setting time increased. Thus, rubber and water did not mix properly during batching thereby increasing the initial and final setting time.

For waste glass added to mortar cement, the initial setting time was found to be reduced significantly compared to that of OPC .This attributed to the weaker cohesion between the waste glass and the cement paste due to their smooth surfaces.

Also when added both waste tire and waste glass together on the mortar show retard the setting time.

Table 11.the result of setting time test

Mix type	Setting time	
	initial	final
M	75	185
MT1	78	190
MT2	89	204
MT3	106	211
MG1	79	188
MG2	89	193
MG3	103	200
MTG1	90	197
MTG2	115	207
MTG3	130	212

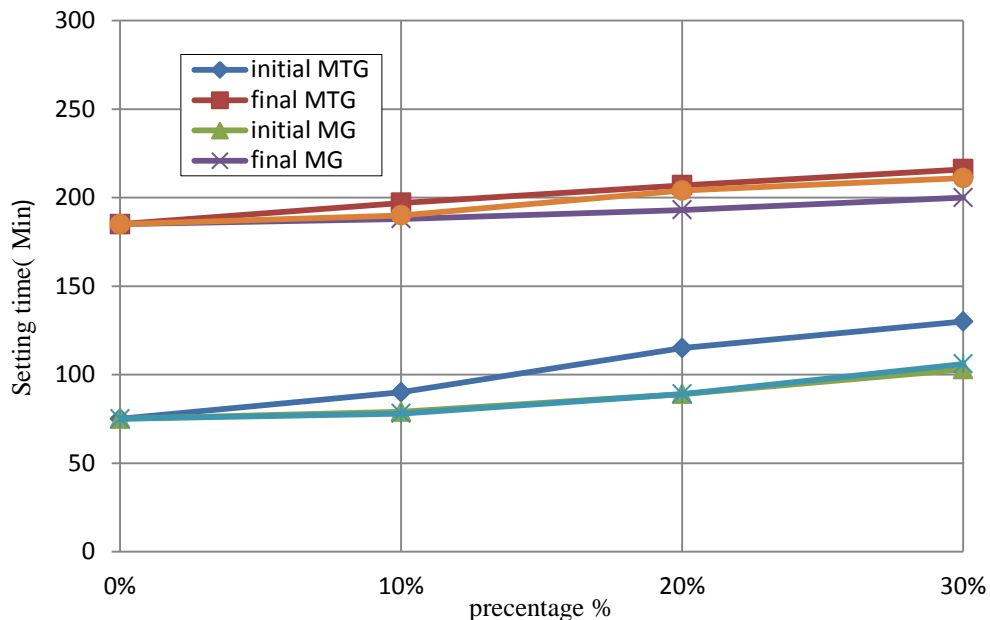


Figure (3-4): Effect of WR, WG on the setting time of cement mortar.

4. Conclusions

From the investigations carried out, the following conclusions can be made

- The compressive strength of mortar reduced as the percentage WR, WG replacement increased.
- The water absorption of mortar increase as the percentage WR, WG replacement increased.
- The densities of mortar reduced as the percentage WR, WG replacement increased.
- The time setting of mortar increase as the percentage WR, WG replacement increased.

5. References

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